I have man additional comments on the documents provided by the Navy, but am attempting to focus with the following themes. Some of these are repeated as they appeared in the "top 10" which the Navy already has and I assume will respond to. I also think Bob's approach to going through the Lines of Evidence is a nice way to tackle this. And lastly, as I noted in the presentation, there are too many statements in the documents that are unsupported, and are either interpretation or conjecture without backup by detailed analysis, or references, etc. I hope that gets cleaned up.

Data Interpretation

1. Geology. More work needs to be done regarding (a) dip and strike, (b) proportions and properties of each significant material type (clean clinker, weather clinker, dense flow interiors, lava tubes, etc.). Some calculations that relate these properties to the parameter values used in the groundwater model would be very helpful to lend credibility to those parameter values (examples we discussed are up-scaling material properties to bulk T values with comparison to Cooper-Jacob or other analyses).
2. Groundwater elevations.
    a. Unfortunately, I think that historical data have had sufficient shortcomings (frequency, location, reference elevation concerns, timing, non-synchronous, lack of knowledge of pumping) that they have caused a lot of discussion and not been amenable to traditional or for that matter non-traditional methods of analysis.
    b. The newly obtained synoptic data provide much better data in terms of frequency, data quality, and knowledge of contemporaneous pumping, that I think interpretation of gradients should emphasize these data more strongly. This is problematic in terms of schedule, but I think the final CSM doc should focus on analyzing these data, and probably down-weight analyses based on the older data. As I attempted to show with the simple head-difference plots, the synoptic shows the effects of pumping clearly on gradients, shows how flat gradients truly are, and also shows gradient reversals (and this is after all appropriate corrections and QA have been accomplished). The Navy may be able to make better or more reliable WL maps, or three-point gradient, or simply paired-gradient calculations, using the synoptic data as the focus.
    c. Lastly, I do think that the synoptic data should be (when using all data, not resampling) amenable to derivative analysis to identify the responses to pumping from Red Hill (which is mostly easy to see) Halawa shaft but also possibly other pumping, and also recharge events. Derivative analysis was not really warranted before with the infrequent data, but the synoptic data cry out for it. I hope we will see some of this in the Dec reports.
3. Groundwater quality data.
    a. I believe it is too early to draw very strong conclusions regarding the extent of contamination, in particular to draw conclusions that infer a very limited extent of impacts to groundwater either via dissolved or LNAPL transport. This is based on the relatively large spacing of monitoring wells, and the complexity of the subsurface. I understand that there is a desire to draw conclusions, and I do think a CSM document has to put forward the best conceptual framework that it can, and show (where possible) where this comports with the available data. However, the data density is low relative to many other sites, and the geology is complex, and that combination of

conditions makes for greater uncertainty on fate, transport, and extent of impacts. The Navy can put forward its perspective and interpretation in its documents, but given the data density, any such statements or presentation should be appropriately and sufficiently caveated that this interpretation is based on a fairly low density of monitoring compared to many or most sites.

4. LNAPL.
    a. I leave that overwhelmingly to Gary but will note that the comments above apply equally or perhaps more so to LNAPL. Indeed, in the case of LNAPL we actually have some evidence for this "hard to predict" / highly variable transport, in the form of the vapor results obtained following the 2014 release. So, while we don't have sufficient data in the groundwater to show that groundwater transport is rapid, complex and not well constrained, we do have data in the vadose zone to show that LNAPL and vapor transport certainly is.

Groundwater Flow Model

1. Parameterization and structure.
    a. Saprolite extent, dip and strike of basalts, cap rock, volcanics, and old sediments. All as noted in the Top 10.
    b. With regard dip-strike, I am hoping that the new grid is aligned with the primary (and new) dip orientation, so that the rotational math can be used to make simple sensitivity analyses (+/- 10 degrees) on this direction without incurring resolution errors. I will be looking specifically for this.
2. Calibration.
    a. Steady-state calibration should focus on demonstrating (a) match with regional patterns and (b) match with representative local gradients under pumping and non-pumping conditions (such as using the method I presented, or some other appropriate method). This combination is required to demonstrate that the model is useful for (a) near-field transport to understand the available groundwater geochemical data, gradients and so on, and (b) developing predictions of capture zones for Red Hill shaft and Halawa shaft that can help the Navy evaluate risk and mitigating / response strategies. While I agree in part with discussions that the model cant represent everything at every scale, unfortunately in this case it has to represent both local and subregional conditions sufficiently well to accomplish these two goals (among others). Scatter plots and residual statistics are not very useful at this site, and better methods need to be used that get to the meat of the issue – flow directions and gradients under pumping and non-pumping conditions.
    b. If they pursue transient calibration to the synoptic as has been discussed, this will provide information on T, S, and possibly on the geometry of features such as the saprolite and anisotropy, but it is not a substitute for getting the gradients right (see above).
3. Predictions.
    a. For the capture zones, I will look for forward tracking that is more comprehensive than the back-tracking used so far. I will also look for a correction to their calculation method, and also not representing it as probability.